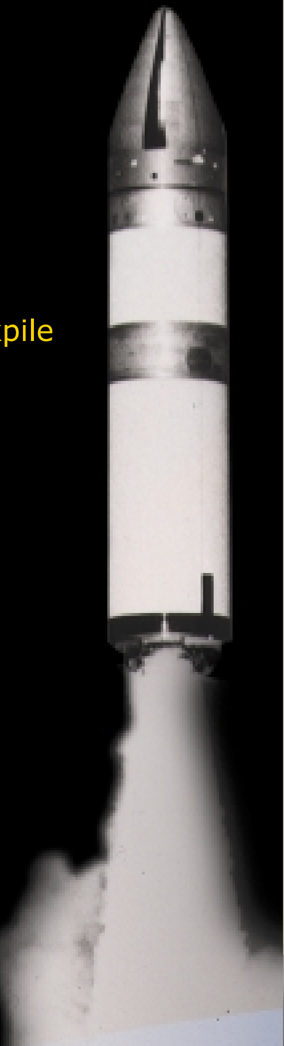

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NNSA

Lawrence Livermore National Laboratory

Making History...

The good news this year at Lawrence Livermore National Laboratory is that we are celebrating our 50th year of service to the nation. The Laboratory was established in 1952 to meet an urgent national security need by helping to advance nuclear weapons science and technology. The grim news for us all relates to the events of September 11, 2001, which remind us of the need for vigilance to keep the nation secure.

The security of the United States has benefited from remarkable advances in science and technology since the end of World War II. At that time, the President's Director of the Office of Scientific Research and Development, Vannevar Bush, helped to steer the nation along the course of continuing government support for long-range research and development. At Berkeley, E. O. Lawrence had created the model of how large-scale science should be pursued—through multidisciplinary team efforts. Lawrence and Edward Teller (below, left, with Herbert York) argued for the creation of a second laboratory to augment the efforts of Los Alamos.

Activities began at Livermore under the aegis of the University of California with a commitment by our first director, York, to follow Lawrence's team-science approach and be a "new ideas" laboratory. Since then, as part of the University with support predominantly from the Department of Energy (DOE) and its predecessors, Livermore has been making history and making a difference.

C. Bruce Tarter, *Director*

50th ANNIVERSARY

In the 1950s, Livermore made its first major breakthrough—the design of a megaton-class warhead for missiles that could be launched from highly survivable submarines. We went on to develop the first high-yield warheads compact enough that several could be carried on each ballistic missile. Further improvements in weapons safety, security, and performance were made in subsequent decades. And, in the past year, we successfully completed a life-extension program to keep the nation's most modern ICBM warhead, the W87, part of the U.S. strategic arsenal well into the 21st century. Also, when the Laboratory opened, we started to explore the feasibility of civilian fusion energy. That quest will come one step closer to fruition through future experiments in the National Ignition Facility.

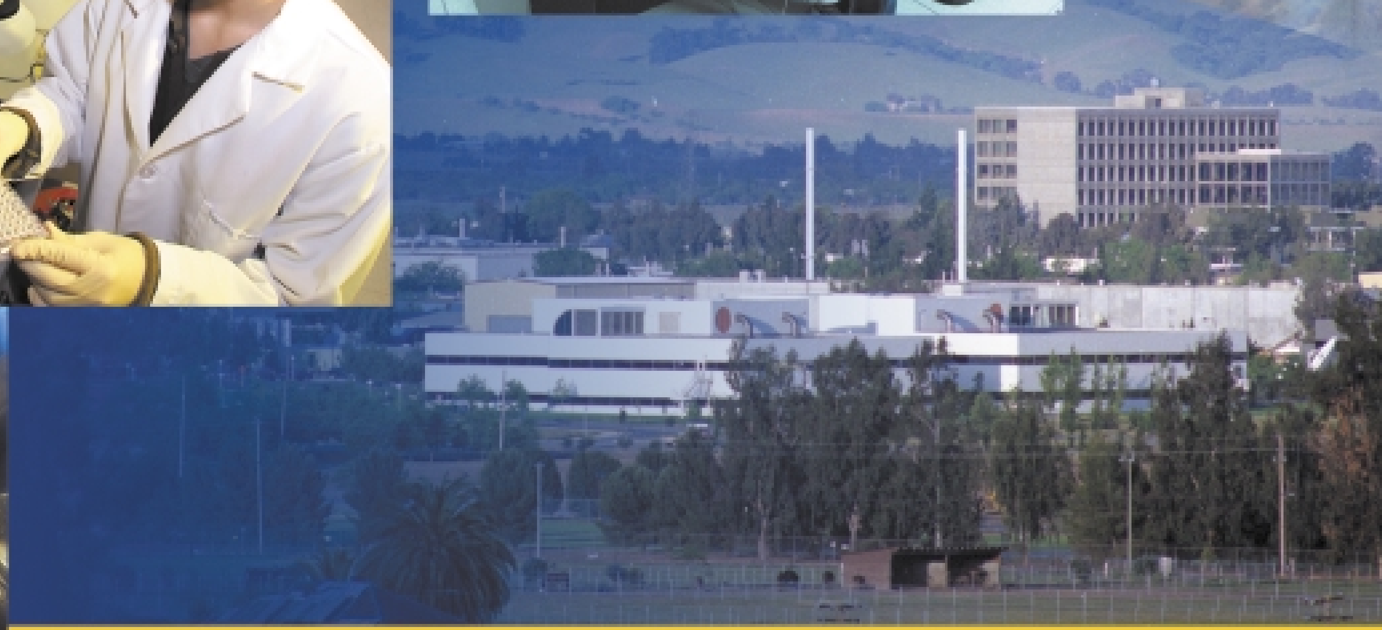
In the 1960s, nuclear testing—including exploration of the peaceful use of nuclear explosives—spawned environmental and bioscience programs at Livermore. Environmental programs have led to novel groundwater remediation technologies in use at Superfund sites, models that are contributing to understanding the human impact on global climate change, and the establishment of the National Atmospheric Release Advisory Center (NARAC) at Livermore. Biotechnology developments at Livermore and Los Alamos, such as chromosome biomarkers and high-speed-flow cell sorters, enabled DOE to launch its Human Genome Initiative in 1986. That initiative grew to become an international effort that completed the draft sequence of the human genome in 2000. Our bioscience program is now assisting national efforts to combat the threat of bioterrorism. Also contributing is our international assessments program, which was established in the 1960s to support the intelligence community.

In the 1970s, Livermore began a laser program, and the Laboratory has been at the forefront of laser science and technology ever since. A sequence of ever-larger lasers to explore inertial confinement fusion has led to construction of the National Ignition Facility (NIF), which will provide essential support to our national security mission. Like its predecessors, NIF will enable new scientific discoveries and is stimulating the development of new products and processes in U.S. industry. The energy crisis in the 1970s also invigorated energy research programs at the Laboratory, which are part of the government–industry partnership to develop long-term reliable, affordable, clean sources of energy.

In the late 1980s, Livermore researchers began to explore the feasibility of using massively parallel processors for scientific computing. For five decades, the need for ever more powerful simulations for nuclear weapons design has guided industry's development of supercomputers. Livermore frequently has been home to "serial number one" of new computers, and we have helped industry make prototype machines ready for a wider range of users. Now massively parallel processing is central to the Advanced Simulation and Computing (ASCI) program, which is a key component of efforts to maintain the nation's nuclear weapons stockpile. "Terascale" computing is also offering unprecedented opportunities for scientific discovery.

In the 1990s, the two major thrusts of our national security mission emerged from the end of the Cold War. Livermore helped DOE to define the Stockpile Stewardship Program, which is ensuring the safety, security, and reliability of the nation's nuclear deterrent in the absence of nuclear testing. We are a key participant in the program and home to unique capabilities for the effort, such as the ASCI White supercomputer and NIF. In addition, in 1991, Livermore expanded its intelligence-support, arms control, and emergency response efforts to create a program focused on an emerging threat—proliferation and use of weapons of mass destruction by terrorists or a nation state. Our expertise and ongoing research, prototype development, and field testing enabled Livermore to respond quickly to the events of September 11. The Laboratory's tools and systems are contributing to homeland security. We will develop even more advanced tools and technologies to cope with increasingly sophisticated threats the nation will face in coming decades.

Our accomplishments in 2001 and our many achievements in 50 years of service to the nation are highlighted in this annual report. Together, they are a credit to the Laboratory's dedicated employees—past and current—and they illustrate the important role of a national laboratory, "making history, making a difference." At Livermore, we are ensuring national security and applying science and technology to the important problems of our time.



...Making a Difference

Lawrence Livermore National Laboratory

Attending to the Needs of the U.S. Nuclear Weapons Stockpile

Lawrence Livermore National Laboratory was established in 1952 to help ensure national security through the design, development, and stewardship of nuclear weapons. Many advances in nuclear design and the capabilities and safety of deployed weapons are attributable to the Laboratory. Livermore is now one of the three national security laboratories that are part of the National Nuclear Security Administration (NNSA) and the Stockpile Stewardship Program to maintain the nation's nuclear deterrent.

Life Extension of the W87 ICBM Warhead

In April 2001, General John Gordon, NNSA administrator, and Admiral Richard Mies, commander-in-chief of U.S. Strategic Command, participated in a ceremony at Livermore to recognize the signing of the W87 Life Extension Program (LEP) Final Development Report. This first completed certification of the engineering design and production processes for an LEP is a groundbreaking milestone for the Stockpile Stewardship Program.

The objective of the LEP has been to enhance the integrity of the W87 intercontinental ballistic missile (ICBM) warhead so that it can remain part of the enduring stockpile beyond 2025 and meet anticipated future requirements. The W87 is the most modern ICBM warhead in the nation's nuclear weapon stockpile. It includes such features as insensitive high explosive and a fire-resistant pit. Together, the W87 warhead and Mk21 reentry vehicle are planned for deployment on the Minuteman-III ICBM when the U.S. ends deployment of multiple warheads on ICBMs.

The successful W87 LEP is an example of the NNSA laboratories and production facilities working together to overcome physics, engineering, and manufacturing challenges and meet Department of Defense requirements without conducting a nuclear test. The development activities conducted by Livermore included extensive flight testing, ground testing, and physics and engineering analysis. Assessment of nuclear performance is based on computer simulation, past nuclear tests, and new aboveground experiments that address specific physics questions raised by the engineering alterations and computer simulations. The first refurbished unit was completed in February 1999, and the final production unit is scheduled for completion in 2004.

In addition, Lawrence Livermore and Sandia National Laboratories, California, have been assigned by NNSA responsibility for the program to extend the life of the W80 cruise missile warhead. After production of the refurbished warheads, Livermore will be responsible for continuing evaluations of their performance. Los Alamos, which originally designed the W80, will retain this responsibility for unrefurbished W80s.

1950s

Breakthroughs in nuclear weapon design by the Laboratory made it possible to deploy a megaton-class warhead on submarine-launched ballistic missiles (SLBMs). Polaris submarines, each equipped with 16 SLBMs carrying Livermore's W47 warhead, provided the nation a highly survivable retaliatory capability to deter a Soviet attack.

1960s

Building on the advances for the Polaris program to make thermonuclear designs smaller, Livermore developed the first weapons for ballistic missiles that carried multiple warheads. These included the W62 for Minuteman-III ICBMs (three reentry vehicles each) and the W68 for Poseidon C-3 SLBMs (10 reentry bodies each).

1970s

With Europe central to the Cold War confrontation, modernization of the theater nuclear forces for NATO was a priority. The Laboratory developed the W70 warhead for the Lance missile, the W84 for the ground-launched cruise missile, and enhanced radiation designs for a modification to the W70 and the W79 8-inch artillery shell.

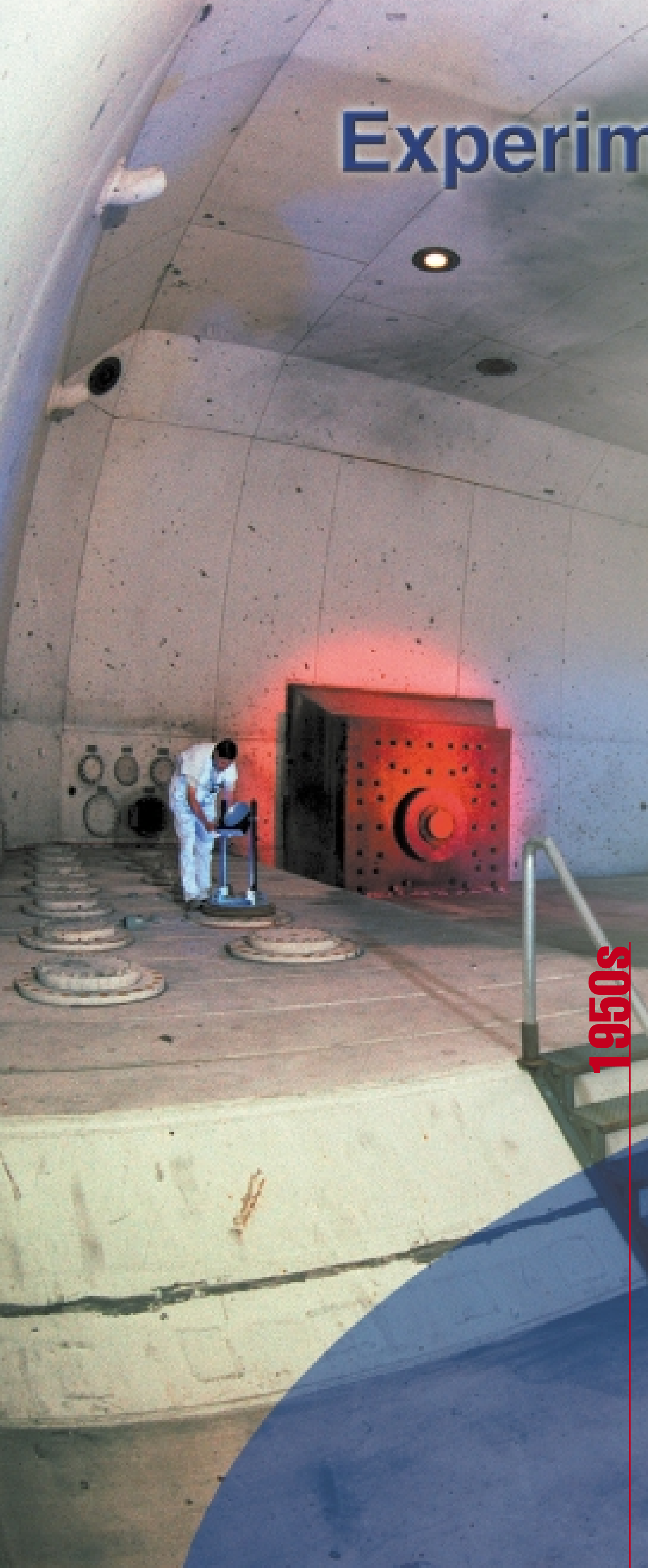
1980s

U.S. strategic force modernization programs led to the weapon systems that comprise today's nuclear deterrent, including two Livermore-developed systems, the B83 strategic bomb and the W87 ICBM warhead. Research at the Laboratory also explored the feasibility of nuclear directed-energy weapons, such as the x-ray laser, for defensive applications.

1990s

With a moratorium in place on nuclear testing, the Laboratory enhanced its efforts and capabilities to ensure that deployed nuclear weapons remain safe, secure, and reliable as they continue to age. These activities, which support annual certification of the weapons and weapon refurbishment programs, are part of the nation's Stockpile Stewardship Program.

Experiments to Understand Nuclear Weapon Performance



Benefiting from nearly four decades of nuclear testing, Livermore scientists and engineers vastly improved the performance and safety of weapon systems that comprise the nation's nuclear deterrent. In the absence of nuclear testing, decisions and actions about the stockpile still must be grounded in experimental reality. To ensure stockpile performance today, nonnuclear experiments—coupled with advanced computer simulations—are used to achieve a highly sophisticated understanding of underlying physics and engineering issues.

Dedication of the Contained Firing Facility

In August 2001, more than 200 dignitaries, employees, and community guests participated in a dedication of the new Contained Firing Facility (CFF) at Site 300, an experimental test area 24 kilometers southeast of the Laboratory's main site. Participants included NNSA Administrator General John Gordon, UC Vice President for Laboratory Management John McTague, and NNSA's Oakland Operations Manager Camille Yuan-Soo Hoo.

The CFF houses the Laboratory's most modern capabilities for conducting hydrodynamics tests. In these critically important experiments for stockpile stewardship, scientists study the performance of mock weapon primary pits as they are imploded by high explosives. With construction of the firing chamber completed, the debris from test explosions is contained in a more environmentally benign manner than ever—dramatically reducing particle emissions and minimizing the generation of hazardous waste, noise, and blast pressures.

In an area 16 by 18 meters and standing 10 meters high, the firing chamber is designed to withstand repetitive tests that use up to 60 kilograms of high explosives (equivalent to 2,000 hand grenades). Walls are up to 2 meters thick and protected from shrapnel by 50-millimeter-thick steel plates. Construction required as much concrete and steel as the frame of a typical 60-story office building. Ventilation, filters, and a water wash-down system clean the chamber after each experiment and effectively manage generated waste.

In addition to the new firing chamber, the CFF houses one of the world's most capable x-ray radiography machines, a complete suite of diagnostic equipment, and a staging area for experimental preparations. "Core punch" experiments probing the detailed shape of the gas cavity inside a pit when it is highly compressed were first conducted at this bunker in the 1980s. Major improvements were made during the 1990s, including the introduction of digital imaging techniques. Before suspension of operations for CFF construction, these experimental capabilities were used to carry out the first core punch experiments on two types of stockpile weapons: the W76 SLBM warhead and the B83 strategic bomb.

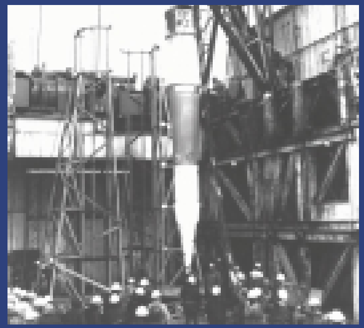
1950s

Six months after opening, Livermore conducted its first nuclear test, RUTH, to explore a novel design concept. It fizzled. However, subsequent tests led to development of the Polaris warhead and included the first contained underground nuclear explosion, RAINIER. That experiment paved the way for an atmospheric test ban.

1960s

After the Soviets broke a moratorium, the U.S. resumed nuclear testing and scientists conducted their last atmospheric tests in 1962. Rapid advances in nuclear design benefited from frequent underground tests and newly developed capabilities at Livermore that included radiographs of imploding mock weapon pits in nonnuclear hydrodynamics tests.

1970s



Described as being under 5 megatons, CANNIKIN set many records when successfully executed at Amchitka Island, Alaska, in 1971. The experiment, weighing over 400 tons, was lowered down a hole 6,150 feet deep and 90 inches in diameter. Its many technical breakthroughs in nuclear-test equipment and extensive diagnostics accentuated a continuing trend.

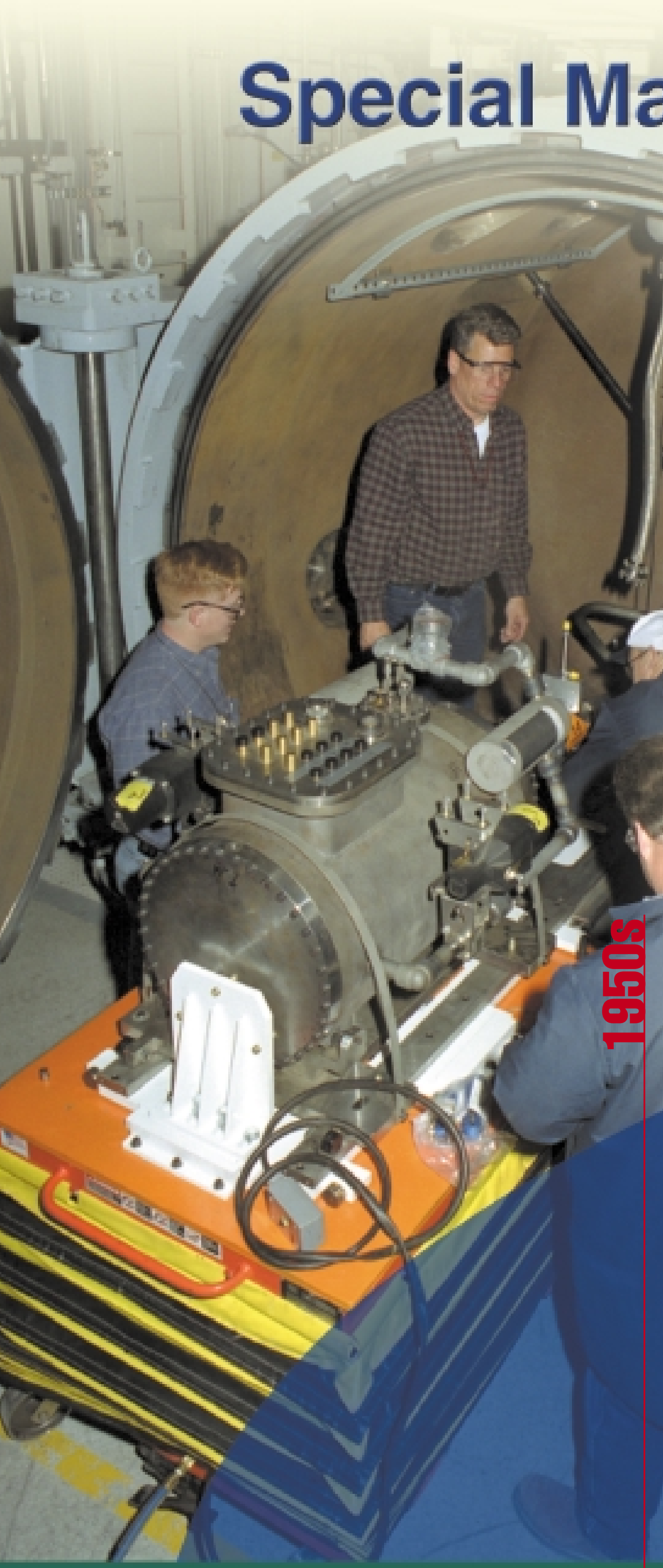
1980s

Livermore conducted many of its most complex nuclear tests and markedly improved its nonnuclear experimental capabilities. The Laboratory brought into operation its High-Explosive Applications Facility for work on energetic materials, the Flash X-Ray Facility for hydrodynamics testing, and the Nova laser for inertial confinement fusion experiments.

1990s

With a U.S. moratorium on nuclear testing, the Laboratory dramatically increased its reliance on nonnuclear testing as part of the Stockpile Stewardship Program. Many new experimental capabilities, including the fielding of subcritical experiments at the Nevada Test Site, help researchers to better understand how plutonium ages.

Special Materials for Weapons and Other Applications



Nuclear weapons include highly reactive metals—plutonium and uranium—as well as organic compounds that degrade over time from exposure to radiation, high temperatures, and accumulated gases. Thus, ensuring the performance of an aging stockpile is a major challenge, but far from the only one facing chemists and materials scientists at the Laboratory. They are frequently tasked to develop or evaluate the performance of novel materials to be used in very demanding applications.

Modeling and Experiments to Understand Plutonium

One major success story of the Stockpile Stewardship Program is the significant improvement that researchers are making in understanding the extremely complex material properties of plutonium. As the plutonium in deployed weapons grows older, the effect of aging-related changes on weapon performance must be thoroughly understood. To this end, scientists at Livermore and Los Alamos are pursuing a comprehensive program of theoretical studies, computer simulations, shock-physics tests, and laboratory experiments.

An important new research tool came on line in 2001, the Joint Actinide Shock Physics Experimental Research (JASPER) Facility at the Nevada Test Site. Livermore has taken the lead for NNSA in constructing JASPER and bringing it into operation.

JASPER's two-stage gas gun accelerates projectiles to speeds of nearly 8 kilometers per second to produce an extremely high-pressure shock wave in a target. The facility is designed for the use of uranium and plutonium targets. Researchers will soon begin to collect valuable equation-of-state data to augment information gathered from high-static-pressure (diamond anvil) experiments conducted at Livermore and from subcritical tests.

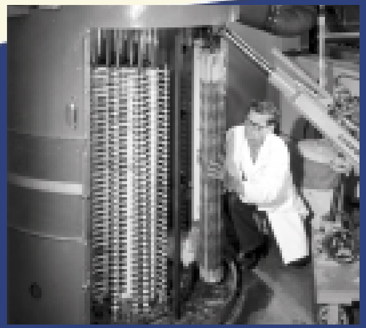
In 2001, Livermore also completed its last two of eight subcritical tests in the Oboe series and prepared for its next experiment, Piano. Conducted in an underground tunnel at the Nevada Test Site, these highly instrumented experiments provide data on the behavior of plutonium when it is strongly shocked with explosives and how that behavior depends on the plutonium's age. Test diagnostics include a laser-based system to obtain holographic images of plutonium ejecta from the shocked surface at the moment of explosion. The film images, when projected with a laser, allow experimenters to see in three dimensions a cloud of plutonium and analyze the size, shape, and velocity of the particles.

Complementing the shocked-material experiments are a combination of computer simulations and laboratory experiments. They are providing new insights about the long-term effects of radiation on materials—for applications ranging from pressure vessels in nuclear reactors to radioactive waste containers to components of nuclear warheads.

1950s

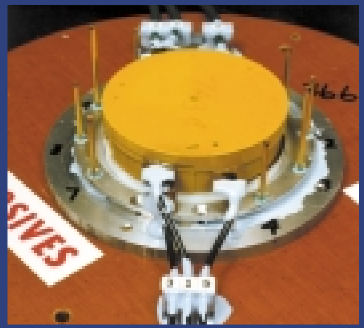
From its beginning, the Laboratory has pursued research on actinides, including uranium, plutonium, and heavier elements. The research has led to current efforts to understand the effect of aging on plutonium in weapons and the recent discovery—with Russian collaborators—of element 114, which is the heaviest element and comparatively long-lived.

1960s



The development of special materials for special applications has been the hallmark of many Livermore programs. For the Pluto "flying" nuclear reactor, a prototype of which was successfully tested in the 1960s, chemists and materials scientists were challenged to develop mass-producible ceramic fuel elements that would work in very stressful operating conditions.

1970s

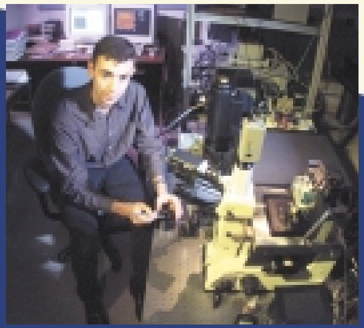


Livermore and Los Alamos developed insensitive high explosives to improve weapon safety. Researchers also began to explore the properties of fiber composites for a wide range of applications. Many projects focused on ensuring the compatibility of the many disparate materials that must coexist for decades inside nuclear weapons.

1980s

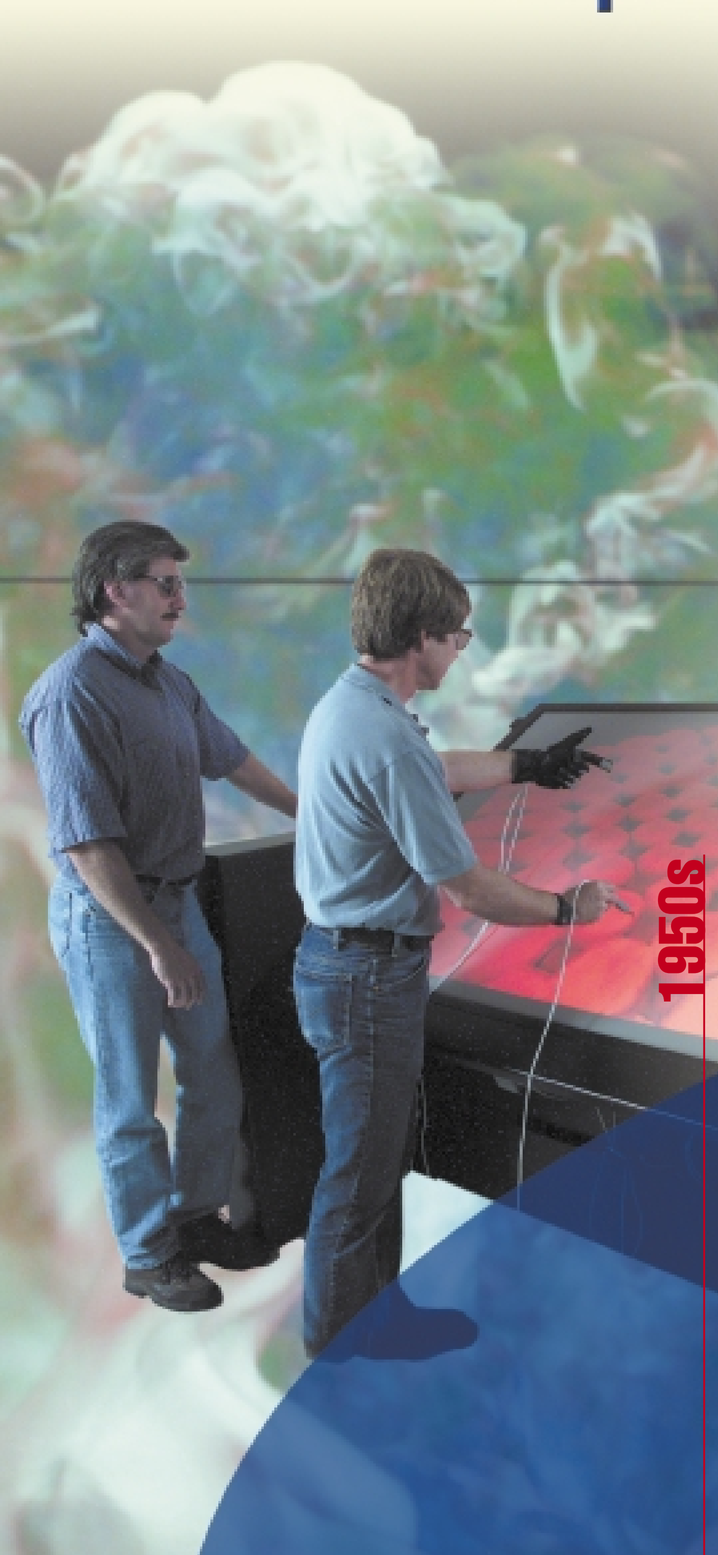
Extreme materials, such as ultralight aerogels used on the Mars Explorer, were developed for special applications. Powerful lasers and two-stage gas guns were used to study materials under extreme conditions, leading to the creation of metallic hydrogen in the 1990s and much better data to characterize deuterium at starlike conditions.

1990s



Experimental and computational capabilities are enabling Laboratory researchers to understand the behavior of materials from the atomic level to the bulk-properties level. Nano-engineered and computer-designed materials are providing ultrahigh strength, ultrahigh capacitance, and unique optical properties to meet demanding programmatic needs.

Improving Capabilities to Simulate Weapon Performance



Acquisition of the Univac-1, and the IBM 701 soon after that, marked the beginning of the Laboratory's not-so-coincidental links to commercial supercomputing. Industry's development of ever-more-powerful machines and Livermore's use of them to explore the design and simulate the performance of nuclear weapons have been closely aligned ever since. Currently, the Laboratory is fully engaged in NNSA's Advanced Simulation and Computing (ASCI) program, a vital component of the Stockpile Stewardship Program to ensure the performance of the nation's nuclear deterrent.

ASCI White—the World's Fastest Supercomputer—and Beyond

Livermore is home to the world's most powerful supercomputer, ASCI White, which is capable of performing more than 12 trillion operations per second (12 teraops). Developed by IBM and delivered in 2000, the machine was used in 2001 to simulate in three dimensions the performance of a nuclear weapon secondary. ASCI White consists of 8,192 IBM processors and is located in a 20,000-square-foot computer room—larger than two basketball courts. The machine has rotating storage memory large enough to store the information in 300 million books.

In August 2001, distinguished representatives from NNSA, IBM, and the University of California came to Livermore to celebrate the highly successful partnership with IBM that led to ASCI White. The supercomputer—which was acquired through ASCI, a key component of the Stockpile Stewardship Program—is rapidly advancing the state of the art in computers, modeling techniques, and data-management tools needed to simulate the performance of nuclear weapons.

Expansion of Livermore's computing power beyond ASCI White requires construction of the $92-million Terascale Simulation Facility (TSF), which is about to begin. The TSF, also a part of ASCI, is designed to accommodate a 60- to 100-teraops machine that will move scientists closer to the goal of performing full-scale simulations of weapons performance based on first-principles physics. The TSF will also house a growing support staff and researchers who work on projects such as developing new tools to assimilate the vast amount of data generated.

In addition to acquiring the larger ASCI machine, the Laboratory will be working with IBM to jointly design a new supercomputer called Blue Gene/L. This expansion of IBM's Blue Gene research project was announced in November 2001. The 200-teraops machine will be capable of performing an important subset of computational problems—those which can be easily divided to run on many thousands of processors. Blue Gene/L will be 15 times more power efficient yet take up less space than other ASCI machines.

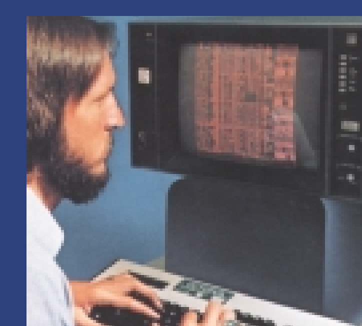
1950s

The Laboratory's founders recognized the need for "supercomputers" in weapon design, and a Univac-1 was installed in April 1953. It was soon augmented by the more powerful IBM 701 and successor machines. To increase productivity, Livermore researchers contributed to developing a much needed higher-level programming language, Fortran.

1960s

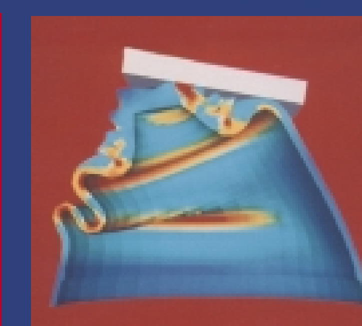
Control Data Corporation (CDC) became the sole supplier of mainframes to meet the Laboratory's needs for high-performance computers. CDC 3600s, 6600s, and 7600s were Livermore's computational workhorses for over a decade, and the Octopus timesharing system was developed to meet the needs of the weapons program's many users.

1970s



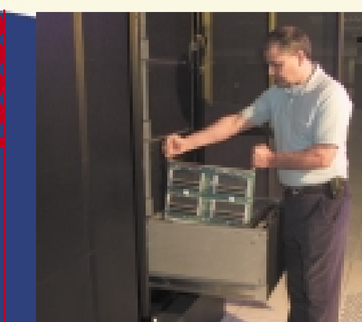
The Television Monitor Display System (TMDS) was an important addition to the Laboratory's Octopus network, providing each user with efficiency-improving visual information. Data management systems continued to improve, but a plateau had been reached in computer speed, leading to the exploration of vector processing machines and acquisition of CDC STARs.

1980s



With the first Cray-1 arriving in 1979, Cray Research became the principal supplier of mainframes to the Laboratory. Cray-1 machines increased computational power by a factor of four over CDC 7600s. They enabled researchers to begin to explore three-dimensional (3D) calculations, including development of the widely used DYNA3D code.

1990s



Exploration of the use of massively parallel computers by Laboratory researchers in the early 1990s was followed by the establishment of the Stockpile Stewardship Program's ASCI. Through a highly successful government–industry partnership, IBM Blue Pacific supercomputer and ASCI White—the world's most powerful computer—are now at Livermore.

Greater Experimental Capabilities to Come

The greatest challenges in stockpile stewardship lie ahead as weapons continue to age. Success depends on bringing into operation vastly improved scientific capabilities, including the National Ignition Facility (NIF). With NIF, scientists will perform vitally needed thermonuclear weapons physics experiments. Offering the promise of reaching the long-sought goal of thermonuclear ignition and energy gain, NIF is the latest in a 30-year history of laser design, construction, and operation at Livermore to achieve inertial confinement fusion.

NIF Progress and Completion of Conventional Construction

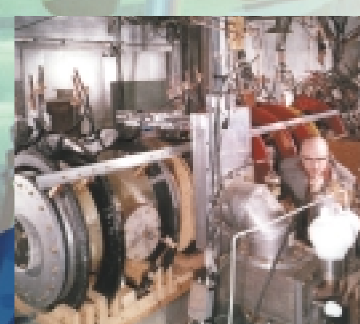
Significant progress was made in 2001 on construction of the National Ignition Facility (NIF). A major milestone was reached in September with completion of NIF's conventional facilities—the stadium-size laser and target building and the optics assembly building. In October, the project completed installation of one-quarter of NIF's beampath infrastructure. Now in place are the precision-cleaned enclosures for the components of 48 laser beams. A strong partnership between the Laboratory, Jacobs Facilities Inc. (the contractor for installation, management, and integration), and the local building and crafts trade unions has enabled the project to achieve these key milestones.

The NIF team continues to make outstanding technical progress. Nearly 80 percent of the required 3,072 high-quality laser glass slabs are ready, and over half of the large crystals used for optical switches and frequency conversion have been grown. New Livermore-developed optical finishing techniques show promise for increasing the durability of NIF's final optics. The clean-room facilities are being commissioned, and production has begun on some components. NIF's clean assembly, transport, and installation requirements were validated with the installation of a laser-glass slab assembly into the main amplifier.

The NIF team's goal is to achieve "first light" in 2003 by delivering 10 kilojoules in four infrared laser beams through the entire laser chain into a diagnostics station. Soon thereafter, these four laser beams will be transported to the final optics assembly, where they will be converted to ultraviolet light and focused to the center of the target chamber. This achievement will provide validation and confidence in all of NIF's systems and will allow commissioning activities to begin.

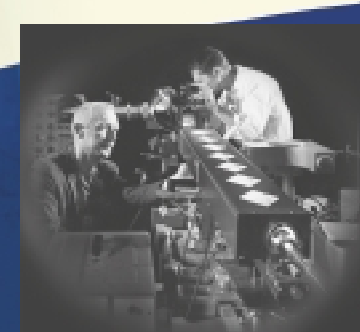
As more of NIF comes on line, fundamental physics regimes for materials science, high-energy-density science, and thermonuclear ignition and burn will become accessible for study. NIF will provide temperatures and pressures needed to validate computer codes and address important issues of national security and basic science.

1950s



To accelerate improvements to the U.S. strategic arsenal, Laboratory scientists worked to develop a better theoretical understanding of thermonuclear weapon design. At the same time, Project Sherwood was exploring the possibility of controlled fusion. An interest common to both was fielding the smallest thermonuclear event feasible.

1960s

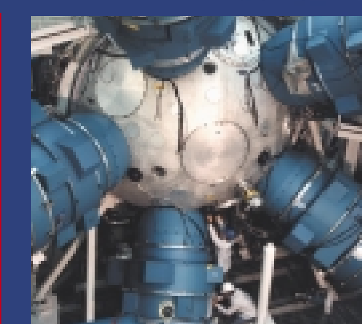


Shortly after the laser was invented in 1960, Livermore scientists performed computer calculations to study the possibility of using powerful lasers to compress and ignite a small quantity of deuterium–tritium fuel. In 1962, the Laboratory began a small project to explore the possibility of laser fusion and other laser applications.

1970s

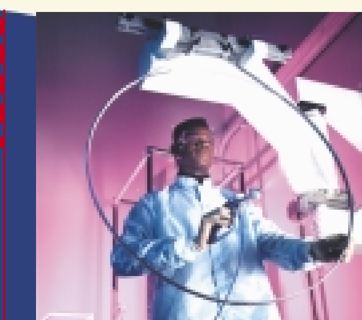
Improved computer calculations showed that important laser fusion experiments could be performed with a 10-kilojoule laser and that ignition and significant gain could be achieved with a megajoule-size laser. Livermore's Inertial Confinement Fusion (ICF) program was born in 1972, and by 1974, the first ICF laser, Janus, was built.

1980s



Experiments on Shiva and Novette paved the way for Nova, a 10-beam laser that became operational in 1985. Using Nova and other lasers, as well as underground nuclear experiments, scientists made important progress in understanding ICF. A powerful x-ray laser was produced using a special two-beam configuration of Nova.

1990s



Nova experiments contributed to stockpile stewardship science and engineering issues, and petawatt power levels were demonstrated on Nova. Using the Beamlet laser, Laboratory researchers achieved breakthroughs needed for the National Ignition Facility (NIF). Construction of NIF, a cornerstone of the Stockpile Stewardship Program, began in 1997.

Reducing Threats and Dangers to the Nation

Throughout the Laboratory's history, researchers have provided technology, analysis, and expertise to help reduce the dangers facing the nation. During the Cold War, a major focus was arms control with the Soviet Union. With the collapse of the Soviet Union, today's grave concern is the threat of the spread of materials and expertise related to weapons of mass destruction (nuclear, biological, and chemical) from Russia to terrorists or countries of concern.

Cooperative Support to Enhance the U.S.–Russian Relationship

Through the Materials Protection, Control and Accounting (MPC&A) program, Russia is receiving assistance to improve protection of its vast quantities of Soviet-legacy nuclear material. Laboratory researchers lead project teams for Chelyabinsk-70, Sverdlovsk-44, Bochvar Institute, and Krasnoyarsk-45 and provide project support for seven other sites. Of the various laboratories involved in the MPC&A program, Livermore is unique in its role with the Russian Navy. Since 1997, upgrades for four nuclear refueling ships have been completed and commissioned, and cooperative work at Russian naval nuclear weapon storage sites is under way. Through the Second Line of Defense program, the Laboratory is working with the Russian Customs Service to curtail the smuggling of items of nuclear proliferation concern by equipping high-risk border crossings with radiation detection equipment and training front-line customs officials in the use of the equipment.

To help accelerate the downsizing of the Russian weapons complex and to prevent displaced weapons workers from seeking employment with potential proliferators, the U.S. and Russia have launched the Nuclear Cities Initiative. In September 2001, lengthy negotiations led by Livermore scientists culminated in a formal partnership agreement between the Avangard Electromechanical Plant (a weapons assembly facility) and Fresenius Medical Care (the world's largest provider of products for individuals with chronic kidney failure) to establish a commercial medical products manufacturing facility at Sarov. This agreement represents a major milestone in U.S. efforts to engage a Russian serial production facility.

Cooperation through science and technology can provide an avenue of engagement in regions of U.S. national security concern, such as the Middle East and Central Asia. Laboratory researchers are participating in regional cooperative projects on such topics as border security, seismology, and water resources. These projects are providing tangible benefits with respect to reducing smuggling across borders and mitigating environmental stresses that undermine public health, the economy and standard of living, and ultimately the stability of the region.

1950s

Livermore conducted the RAINIER event, the first contained underground nuclear test. The data gathered on underground explosion phenomenology provided the technical basis for subsequent agreement to the Limited Test Ban Treaty, which banned testing in the atmosphere, outer space, or underwater and established systems for monitoring nuclear test activities worldwide.

1960s

Photo: Lawrence Berkeley National Lab

Many Laboratory scientists participated in the technical working groups that supported Limited Test Ban Treaty (LTBT) negotiations, and these activities gave rise to new programs to detect nuclear explosions. President Kennedy and Premier Khrushchev signed the LTBT in 1963, and President Johnson signed the Nuclear Non-Proliferation Treaty (NPT) in 1968.

1970s

Photo: Bettman/UPI

Former Laboratory Director Michael May served as Technical Adviser to the Threshold Test Ban Treaty (TTBT) negotiations (1974) and as U.S. Delegate to the Strategic Arms Limitations Talks (SALT, 1974–76). Signed but never ratified, the SALT II agreement capped the growth of strategic nuclear arsenals during the Cold War.

1980s

TTBT verification issues were resolved with the Joint Verification Experiment (JVE), a pair of nuclear tests jointly carried out at the U.S. and Soviet test sites. Laboratory experts provided technical advice for both the JVE and the negotiations for the Strategic Arms Reduction Treaties (START, 1991–96), which would limit and then eliminate MIRVed ICBMs.

1990s

U.S. nuclear testing ceased, and a Comprehensive Nuclear Test Ban Treaty (CTBT) was signed. Livermore technical advisors served at the CTBT talks and preparatory commission. After the Soviet Union collapsed, Livermore, Los Alamos, and Sandia national laboratories established cooperative programs with former-Soviet labs to prevent the spread of weapons expertise or materials to other nations.

Anticipating and Responding to Emerging Threats

Since its inception, Livermore has been committed to being a "new ideas" laboratory—recognizing technical opportunities to enhance security, anticipating future national needs, and responding to emerging threats. Livermore is a source of expertise in such areas as biodefense, counterproliferation analysis, missile defense, advanced munitions, and energetic materials. Ongoing Laboratory efforts to improve the nation's ability to prevent and mitigate terrorist use of weapons of mass destruction (WMD) proved timely in 2001.

Technology for Homeland Security

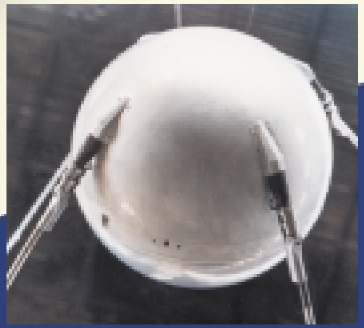
A critical element of U.S. national security is avoiding surprise regarding the weapon capabilities, intentions, and motivations of other countries and terrorist groups. We conduct all-source analyses related to foreign development and deployment of nuclear weapons and other weapons of mass destruction (WMD).

After September 11, the Laboratory provided analysts and assessments as well as information-operations tools and expert personnel to the U.S. Intelligence Community. Livermore's Nuclear Threat Assessment Center was operated seven days a week to evaluate numerous smuggling incidents and nuclear-related threats.

As the anthrax mail cases illustrated, the U.S. is vulnerable to bioattack. Livermore technologies are at the core of the nation's biodefense capabilities. The Laboratory's miniaturized DNA analysis technology has been commercialized by Cepheid Inc. as the Smart Cycler and by Environmental Technologies Group as a handheld instrument. With both instruments, results are available in minutes. The Biological Aerosol Sentry and Information System (BASIS), developed jointly by Livermore and Los Alamos, was deployed to Salt Lake City as part of the overall security strategy for the Winter Olympic Games; Smart Cyclers are the heart of the BASIS field laboratory. Livermore is also developing "gold standard" DNA signatures and assay protocols, which are validated by the Centers for Disease Control and Prevention (CDC) and then distributed by the CDC to the public health community.

Livermore's Counterproliferation Analysis and Planning System (CAPS) is widely used by U.S. military planners to evaluate proliferators' WMD production capabilities and assess interdiction options. Last year, CAPS analyzed 18 WMD programs worldwide at more than 500 sites. Immediately after September 11, the CAPS team focused on sites of concern in and around Afghanistan to support U.S. military efforts. The Laboratory is also contributing to the evaluation of candidate missile intercept technologies. Integrated onto a HALO aircraft, Livermore's Remote Optical Characterization Sensor Suite (ROCSS) will observe missile intercept experiments and will spectroscopically "look" for a particular chemical contained in the target warhead and whose release after intercept would indicate target kill.

1950s



The surprise of the Soviet A-test in 1949 and the emerging threat of the Soviet H-bomb led to the creation of Livermore as a second weapons laboratory. Sputnik's launch in 1957 and the perceived "missile gap" spurred the drive for improved U.S. strategic forces and better understanding of Soviet capabilities.

1960s

The Special Projects Group (Z Division) was established in 1965 to provide the intelligence community with technical assessments of foreign nuclear programs and weapons capabilities. Scientists and engineers with weapons-program experience work with regional and country-specific experts to provide multidisciplinary, all-source analyses.

1970s

Livermore's nuclear emergency response capabilities were tested. In Operation Morning Light, members of the Nuclear Emergency Search Team (NEST) assisted Canadian authorities in the 1978 recovery of radioactive pieces of a Soviet satellite that came down in northern Canada. The Atmospheric Release Advisory Center (ARAC) tracked fallout from the Three Mile Island incident.

1980s

Novel nuclear and nonnuclear defense concepts were explored by Laboratory researchers to protect the nation from ballistic missile attack. Brilliant Pebbles emerged as a leading candidate for boost-phase intercept as part of the Strategic Defense Initiative. Key component technologies were demonstrated when the Clementine spacecraft mapped the Moon.

1990s

Livermore provided analyses of WMD activities worldwide. Laboratory experts participated in post–Gulf War inspections in Iraq. Researchers developed the Counterproliferation Analysis and Planning System (CAPS), which is widely used by the Department of Defense, as well as improved WMD detection and incident-response capabilities.

Meeting Energy Needs and Managing Nuclear Materials

As a national resource, Livermore is part of the government–industry partnership to meet long-term needs for dependable, affordable, clean energy. The Laboratory has a long history of contributing, particularly in research areas—such as fusion energy and management of nuclear materials—that align with Livermore's national security mission or draw on special expertise. Energy research projects benefit from Livermore's multidisciplinary approach to problem solving and integrated capabilities that extend from basic science to prototype demonstration.

Technical Support for the Yucca Mountain Project

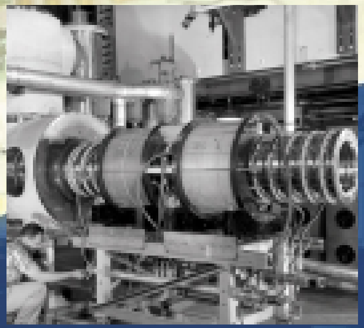
In January 2002, Secretary of Energy Spencer Abraham notified the governor of Nevada of his intention to recommend to the President approval of the Yucca Mountain site for the development of a repository to store up to 77,000 tons of high-level radioactive waste. Subsequently, President Bush gave his authorization, and State of Nevada officials expressed their disapproval and intention to take actions to stop the project.

A solid technical foundation is vital for the Yucca Mountain Project and political decisions concerning its future. The Laboratory has been helping DOE to address some of the most significant scientific challenges. Livermore led the preparation of three of the nine Process Model Reports—for the waste package, engineered barrier system, and near-field environment. These reports provided support for the Secretary's site recommendation to the President.

In his recommendation, Secretary Abraham concluded that the Yucca Mountain site is scientifically sound and suitable. Before Presidential approval, the Nuclear Waste Technical Review Board, created by Congress to provide technical oversight of the project, reported that they found no single issue that would eliminate Yucca Mountain from consideration. The board did note that scientific uncertainties limited their confidence in long-term projections about performance.

Scientists are conducting materials performance tests to confirm that the waste packages will maintain their integrity over thousands of years. This information is centrally important to decisions about licensing the site and how it is to be operated. The Laboratory has been testing the materials for making waste packages and researching the site's geology to accurately predict the effect of the buried wastes on nearby geology. In addition, using Livermore's supercomputers and new codes to simulate the geologic evolution of the repository, scientists are conducting pioneering analyses of how heat affects the mountain. The simulations are being used to predict the temperature evolution surrounding the buried waste and the possible means by which water might enter the repository tunnels over geologic time periods.

1950s

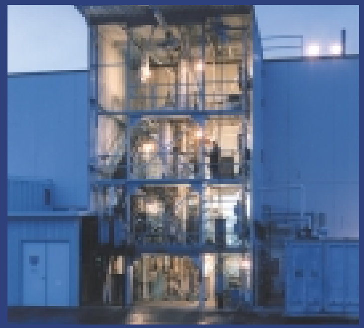


Fusion as an inexhaustible source of civilian power has long been a vision of Livermore scientists. Project Sherwood began as a classified fusion research program when the Laboratory opened. Computer modeling, plasma physics experiments, and studies of materials for reactor walls are the focus of current magnetic-fusion research efforts.

1960s

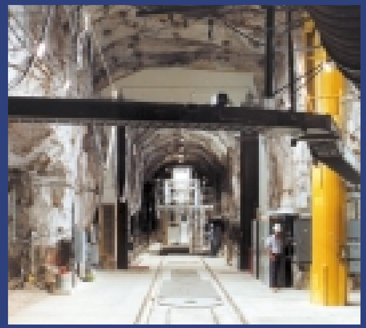
In 1967, the first of three joint government–industry field experiments, GASBUGGY, was conducted to investigate the feasibility of stimulating the production of natural gas in low-yield fields with nuclear explosives. GASBUGGY marked the beginning of continuing Laboratory efforts with industry to improve oil and gas recovery.

1970s



The energy crisis dramatically raised the priority of enhancing the nation's energy security. Laboratory researchers engaged in a variety of energy projects that led to large-scale demonstrations of in situ coal gasification and oil extraction from shale. Other projects focused on battery research, geothermal energy, and energy conservation.

1980s

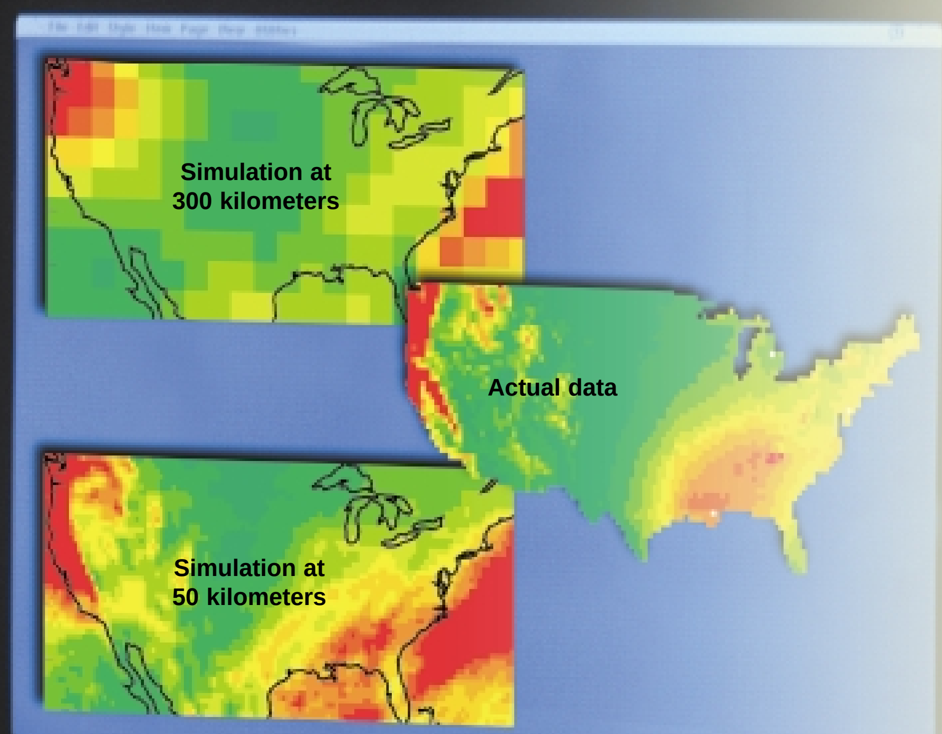


In the early 1980s, the Laboratory conducted the Spent Fuel–Climax experiment at the Nevada Test Site to study the feasibility, safety, and reliability of short-term storage of spent reactor fuel assemblies in granite rock. Livermore was also tasked by DOE to develop the waste package for what became the Yucca Mountain Project.

1990s

Advances by Laboratory researchers furthered the exploration of alternatives to carbon-based fuels and their more efficient use. Significant progress was made on fuel cells, electromechanical batteries, and use of hydrogen as fuel. Continuing reliance on nuclear power raised the need for improved tracking of nuclear materials in the U.S. and abroad.

Preserving the Environment and Managing Carbon



Environmental expertise at the Laboratory arose from the need to understand the consequences of nuclear testing—in the atmosphere and underground. Today, geophysicists are developing innovative tools to characterize and mitigate groundwater contamination and manage nuclear waste. Atmospheric scientists are prepared to assist in the event of hazardous material releases to the atmosphere. They are also improving simulation models to understand the climatic consequences of human activities that produce carbon dioxide and other greenhouse gases.

Improving Global Climate Simulation Models

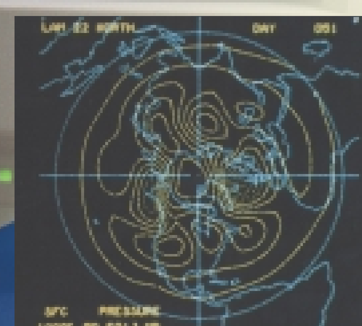
In 2001, Livermore researchers made significant progress applying and further developing global climate simulation models. Because of computational limitations, models today are typically run at 300-kilometer spatial resolution, which does not adequately represent smaller-scale topographic features, such as the Sierra Nevada in California. The results are realistic on a large scale; however, the models do not always accurately simulate climate at regional scales. The modeling results provide an insufficient basis for assessing potential societal effects of climate change (for example, water management and effects on agriculture) in regions such as California's Central Valley.

Taking advantage of terascale computer resources at Livermore, researchers successfully performed global climate simulations at a much finer resolution (50 kilometers) than ever attempted before. As expected, these high-resolution simulations, requiring roughly 200 times more time and 35 times more memory than 300-kilometer simulations, produce much more realistic regional climates. Simulation results of winter rainfall over 10 years are illustrated and compared with actual data.

Another limitation of current models is that atmospheric carbon dioxide (CO_2) concentrations are prescribed, not simulated. Earth's large natural sources and sinks of carbon interact with the man-made emissions and affect CO_2 accumulation. A better model would simulate the global carbon cycle and predict time-evolving concentrations of greenhouse gases using man-made emissions as input.

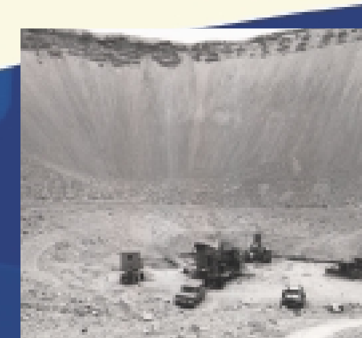
Livermore researchers are developing such a global-scale model—the integrated climate- and carbon-cycle (INCCA) model. To make rapid progress, they are using existing, well-documented models of the atmosphere, ocean, land surface, and aerosol chemistry. The individual models are being integrated into the INCCA system and modified where necessary for use on terascale computers. In 2001, models from the National Center for Atmospheric Research and the University of Wisconsin were acquired and tested. In the coming year, researchers expect to complete the coupling of the full climate and carbon-cycle system. They will then be able to pursue comprehensive predictive simulations, which can be used to evaluate the climatic effect of proposed energy policies.

1950s



In the late 1950s, a Laboratory researcher constructed the first global general circulation model, able to simulate the behavior of large weather systems. Concerns about nuclear winter heightened interest in global circulation models in the 1980s, and in the 1990s, steadily improving models provided evidence of human-induced climate change.

1960s



Interest in the peaceful use of nuclear explosives (Project Plowshare) led to the development of models to accurately estimate fallout, and studies were conducted of the environmental impact of proposed nuclear-excavation projects. Activities in the 1970s evolved into continuing efforts toward helping Marshall Islanders resettle.

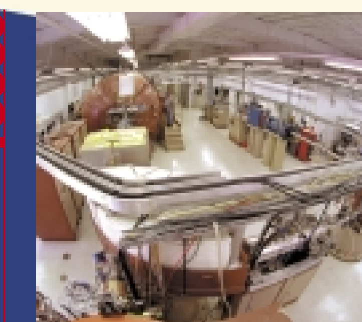
1970s

The Laboratory proposed to DOE the establishment of the National Atmospheric Release Advisory Center (NARAC) at Livermore. NARAC became responsible for estimating the fate of radionuclides in the event of actual or potential releases. During pilot operations in 1979, the center was called for assistance after the Three Mile Island incident.

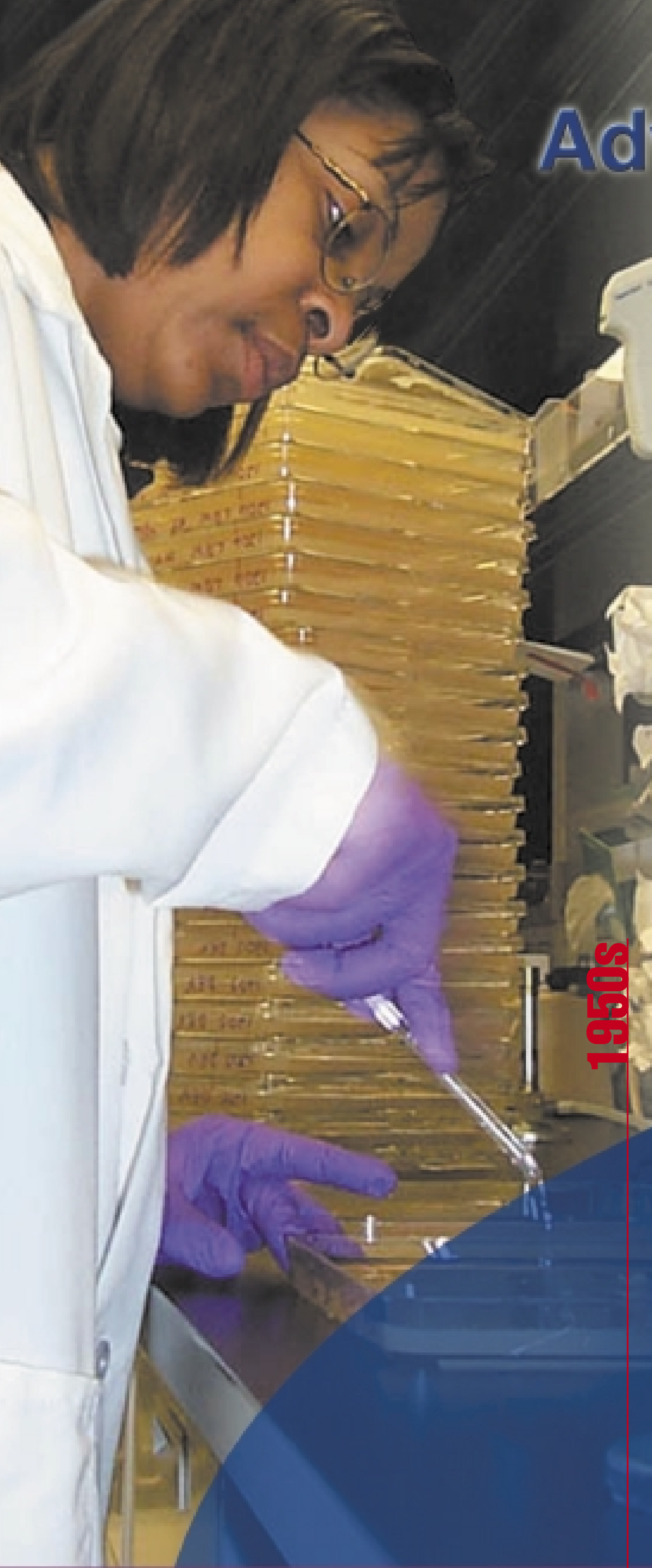
1980s

Livermore researchers developed innovative modeling techniques and technologies for characterizing and remediating groundwater beneath the Laboratory, which had been earlier contaminated by the disposal of hydrocarbons. The techniques are being applied to clean up the Laboratory and Superfund sites elsewhere.

1990s



The Center for Accelerator Mass Spectrometry (CAMS) began operations in 1989 and now processes nearly 30,000 samples per year for users. Able to detect one particular atom out of a quadrillion, CAMS supports projects that range from archaeological dating to biomedical research and from global climate change to national security.



Advancing Bioscience to Improve Human Health

The Laboratory leverages its capabilities in the physical and engineering sciences to conduct research of national importance in bioscience and biotechnology. In partnership with academia, industry, and government, Livermore began the bioscience research program in 1963, with a focus on understanding how ionizing radiation affects human health. The work led to the development of technologies that helped launch the Human Genome Project, and activities now range from research in genomics to counter-bioterrorism to health-care technologies.

Understanding the Human Genome and DNA

An important milestone was reached in 2000 when the DOE Joint Genome Institute (JGI), with researchers from Livermore, Berkeley, and Los Alamos national laboratories, completed a "working draft" sequence of human chromosomes 5, 16, and 19. The accomplishment is a major step—but only the first—toward understanding genetic material. In 2001, Livermore researchers improved the draft sequence and pursued a variety of efforts that make use of the sequencing data and capabilities of the JGI.

To understand the functional significance of DNA sequences, a JGI team led by a Livermore bioscientist compared human chromosome 19 with similar sections of mouse DNA. Their comparative analysis, published in *Science*, found that chromosome 19 had about 1,200 genes, substantiating earlier estimates that human DNA contains about 30,000 genes altogether. The team also discovered "candidate" regulatory sequences. Future research will test the function of these regulatory sequences to determine how and where they activate other genes.

Efforts to sequence mouse DNA, which were carried out in 2000, made possible the comparative study. Sequencing work in 2001 also included studies of the Japanese pufferfish and parts of the *Yersinia pestis* genome. The pufferfish genome is of interest because it is compact yet similar to the human genome. In support of counter-bioterrorism, work on *Yersinia pestis*, the pathogen that causes plague, may lead to a better understanding of the organism's biology, better diagnostic tools, and new vaccines and treatments.

Laboratory scientists also developed a new DNA diagnostic technique that is expected to provide a valuable new tool to improve cancer diagnosis. The advance, described in *Proceedings of the National Academy of Sciences* in December 2001, allows researchers to detect mutations in individual cancer cells by specific identification and by making numerous copies of the DNA in the genes that are important for cancer progression in each cell.

1950s

The Atomic Energy Commission (AEC) began research on the possible biological consequences of fallout after the BRAVO test in 1954, which irradiated Marshall Islanders and Japanese fishermen. A growing need to understand the consequences of nuclear test activities led AEC to establish a limited program at the Laboratory in 1963.

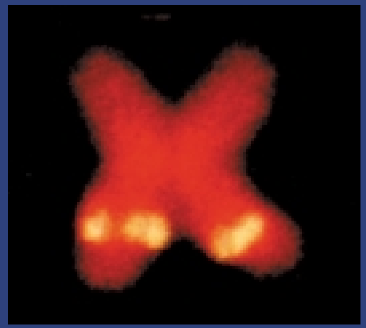
1960s

From its beginning, Livermore's biomedical program has focused on how ionizing radiation and chemicals affect genetic materials to understand health consequences. Researchers developed a computer-based system, CYDAC, to calculate the amount of DNA present in human chromosomes and check for abnormalities.

1970s

Chromosome biomarkers began to be used in studies of genetic damage, first with cultured animal cells. Taking a multidisciplinary approach to bioscience and using its expertise in lasers and engineering, the Laboratory developed tools such as a high-speed flow sorter for analyzing and purifying chromosomes and other molecules.

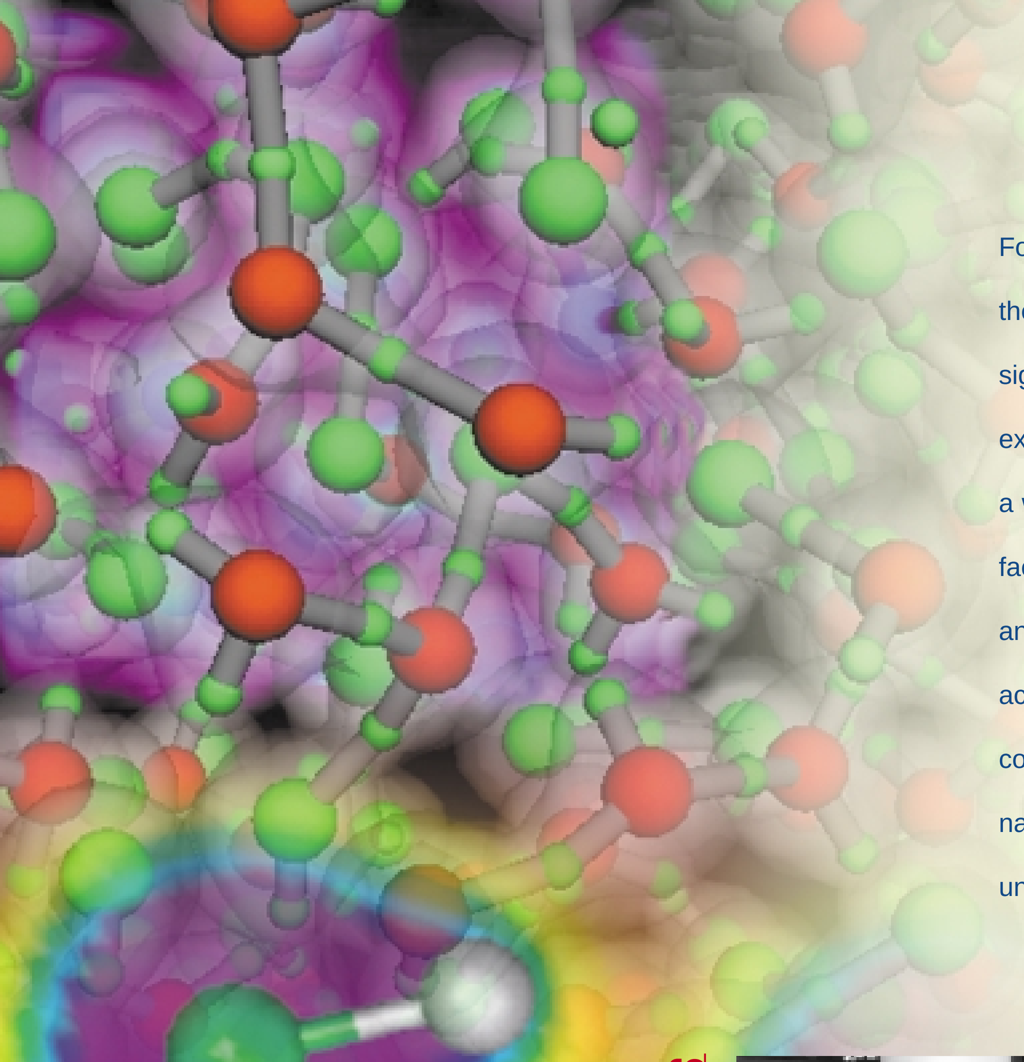
1980s



Tools such as the Laboratory's flow sorter led to chromosome painting in 1988, a much faster method of measuring damage to specific chromosomes. Chromosome research at the DOE laboratories attracted the attention of the National Academy of Sciences, which encouraged DOE's decision to launch the Human Genome Initiative in 1986.

1990s

Livermore's Human Genome Center completed a high-resolution map of chromosome 19 in 1996. Sequencing efforts expanded in 1999 with the opening of the tri-laboratory DOE Joint Genome Institute, which finished draft sequences of three chromosomes in 2000. The causes of several genetic diseases were identified through collaborative research.



Pursuing Breakthroughs in Science

For 50 years, innovative scientific research at the Laboratory has helped the nation deal with significant threats to security. Livermore's exceptional workforce meets the challenge using a wide range of special capabilities and unique facilities. Pursuing demanding problems in basic and applied science, Livermore researchers actively participate in the international scientific community, collaborating with colleagues at other national laboratories, research centers, and universities.

On the Cutting Edge of Scientific Computing

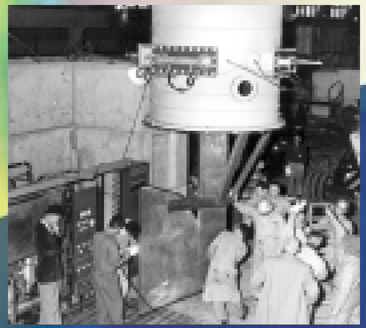
Research projects on the frontiers of scientific supercomputing were featured when Livermore celebrated Science Day on March 21, 2001. Dignitaries, Laboratory employees, invited guests from the local community, and the media gathered to hear presentations, tour facilities, and view poster presentations in the day-long event. Science Day was held to mark the Laboratory's many scientific accomplishments. In attendance were NNSA Administrator General John Gordon, acting DOE Office of Science Director James Decker, and University of California Provost and Senior Vice President C. Judson King.

Science Day presentations demonstrated that high-resolution, three-dimensional (3D) scientific simulations are an essential part of virtually every major program at Livermore. Laboratory researchers summarized work on 8-billion-zone simulations of turbulent mixing, calculations to predict the 3D shape of proteins, multiscale modeling of material properties, and quantum molecular dynamics calculations to determine the properties of matter at high pressure. Simulations are moving from a supportive role for theory and experiments to a starring role—they are becoming a principal tool for scientific discovery and analysis.

Weapon scientists at the Laboratory are moving closer to the goal of full-scale simulations of weapons performance based on first-principles physics models with the advanced computing capabilities made possible by NNSA's Advanced Simulation and Computing (ASCI) program. Other Livermore programs have access to terascale computing through the Laboratory's Multiprogrammatic and Institutional Computing Initiative. Scientific supercomputing is leading to unprecedented levels of understanding in biology, climate and weather modeling, environmental studies, the design of new materials, and many areas of physics.

Some of the cutting-edge scientific research conducted on supercomputers at the Laboratory is supported by DOE's new Scientific Discovery through Advanced Computing (SciDAC) program. In 2001, Livermore and collaborators received more than $23 million from SciDAC to study subjects including supernovae, climate modeling, plasma microturbulence, and development of supercomputer simulation tools. The Laboratory is participating in 10 SciDAC projects and leading 2 of them.

1950s



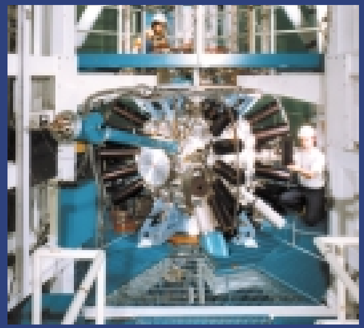
The physics governing nuclear weapons performance was the first focus and remains a continuing one for Laboratory researchers. Throughout its history, Livermore has been at the forefront of studying the properties of matter at extreme conditions (up to stellar temperatures and pressures) and studying the interaction of matter with intense radiation.

1960s

Photo: Adam Block/NOAO/AURA/NSF

Astrophysics and nuclear weapons physics have many similarities, and in the 1960s, Laboratory researchers authored key papers on gravitational collapse and supernova explosions. The discovery of dark matter in the form of massive compact halo objects (MACHOs) is just one recent example of Livermore's continuing contributions to astrophysical research.

1970s



The Laboratory launched its Laser Program in 1972 and, with its 20-beam Shiva laser in 1977, became preeminent in laser science and technology. Break-through advances in lasers and electrooptics include the world's most powerful laser (the Petawatt in 1996), the brightest (JanUSP in 1999), and the largest (the National Ignition Facility under construction).

1980s

Photo: AP/Jonas Ekstromer

Important breakthroughs in the 1980s included work by Robert Laughlin (above, left) on the fractional quantum Hall effect, for which he was awarded a Nobel Prize in 1998, and the development of x-ray lasers. Livermore's Novette laser was used to produce the plasma conditions necessary for lasing to occur at soft x-ray frequencies.

1990s

The cessation of nuclear testing dramatically increased the importance of developing a more thorough understanding of the fundamental physics of nuclear weapons. Begun in 1995, the Stockpile Stewardship Program includes a series of campaigns to make necessaryscientific advances to support assessments of weapon performance.

Tools for Scientific Research and Advanced Prototypes

The tradition of fully integrating engineering expertise into scientific pursuit originates with E. O. Lawrence's team-science approach. As a national laboratory, Livermore is responsible for developing large-scale tools for mission-directed scientific research, such as the National Ignition Facility, and prototypes of systems for sponsors. Ranging from microscale to monumental scale—and frequently demanding ultraprecision and very-high-speed diagnostics—Livermore's prototypes meet important national needs and help push the frontiers of science and technology.

Keck Mirror Coating and Virtual Guide Star

Two projects in 2001 involving Livermore scientists and engineers are dramatically improving the performance of telescopes at the Keck Observatory in Hawaii and elsewhere. In one effort, a new ultrathin silver coating was installed on a 22-inch mirror for use at the Keck Observatory and then on mirrors in several other major telescopes. Patented by two Livermore researchers, the revolutionary technology was developed to protect the thousands of mirrors for flashlamps in the National Ignition Facility.

Livermore's ultrathin silver coatings have higher reflectivity and are far more durable than previously used silver coatings. The higher reflectivity means that large telescopes, which typically reflect the collected light off five or six mirrors, may have up to a 35-percent increase in light-collection efficiency. Samples of the ultrathin silver coating will also be taken to the International Space Station in 2002 and subjected to long-term tests to determine the coating's suitability for Hubble telescope mirrors and other space-based applications.

In a second effort, Livermore researchers and collaborators at the Keck Observatory created for the first time a "virtual" star over Hawaii in December 2001. The star was formed by using a 20-watt dye laser to illuminate a diffuse layer of sodium atoms about 60 miles above the Earth's surface. The sodium atoms produce a very small source of light, which can then be used to measure and correct for the distortions in the atmosphere that cause stars to twinkle.

The real-time control system to correct for the distortions, known as adaptive optics, had previously been developed by Laboratory researchers and installed on the Keck II telescope. With adaptive optics, the telescope's infrared images have four times better resolution than the Hubble Space Telescope. However, the system could be used for only about 1 percent of the sky because it required a sufficiently bright "guide star" near the faint object being studied. Now astronomers can study objects anywhere in the sky by creating a nearby virtual guide star where they need one.

Photo: John McDonald/Canada-France-Hawaii Telescope Corp.

1950s

Significant research facilities constructed in the 1950s included the Livermore Pool-Type Reactor (LPTR) and the 90-inch cyclotron, used until 1971 to gather large amounts of nuclear physics data. Until 1980, the LPTR supported a broad range of projects, from fundamental physics to studies of radiation damage.

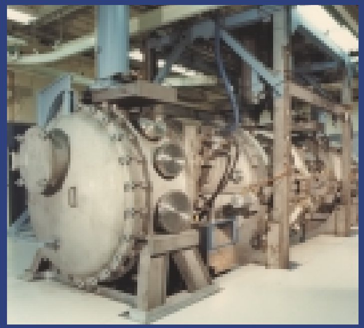
1960s

Two prototype versions of the Pluto ramjet nuclear reactor were designed at Livermore and then built and successfully operated at the Nevada Test Site. Reactor testing required the development of novel remote-handling technologies as well as systems capable of ramming about a ton of heated air through the reactor each second.

1970s

The Laboratory made significant strides in magnetic fusion research through the design, construction, and use of successively larger facilities. The Tandem Mirror Experiment in the 1970s demonstrated markedly improved plasma confinement. It led to design and construction of the Mirror Fusion Test Facility, which was shut down in 1982.

1980s

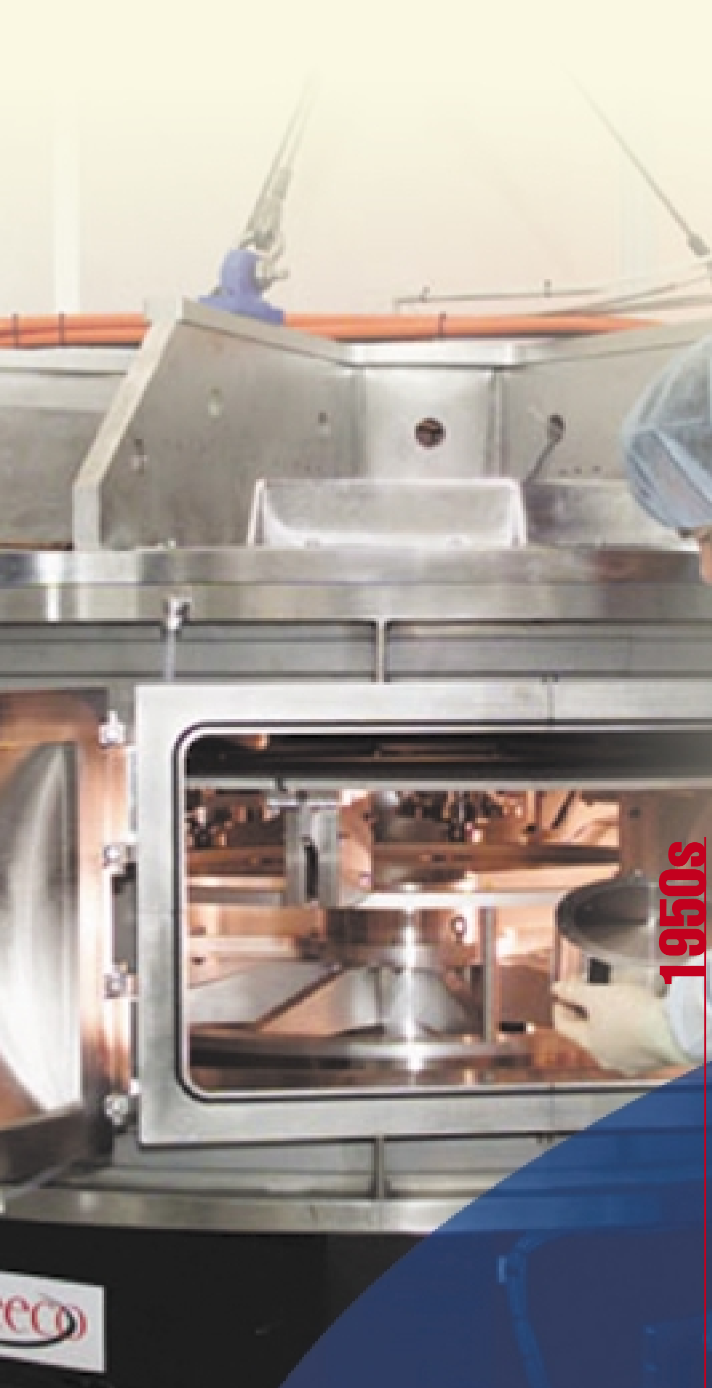


Livermore's progress in large-scale engineering development and demonstration of atomic vapor laser isotope separation (AVLIS) for uranium enrichment led DOE in 1985 to select the technology for further development. Large-scale laser programs such as AVLIS and the Nova laser brought greater industrial involvement with advanced lasers.

1990s

B-Factory construction at the Stanford Linear Accelerator Center was an international collaborative effort. Livermore's involvement has ranged from particle physics to engineering design and precision machining. The Laboratory contributed to three of the seven systems for the B-Factory's detector. Researchers are now engaged in data analysis.

Partnerships That Benefit the Laboratory and U.S. Industry



Since the Laboratory's beginning, many research and development activities have been executed in partnership with U.S. industry, academic institutions, and other laboratories. Partnerships and collaborations are often the most cost-effective way to accomplish the Laboratory's programmatic goals. In addition, Livermore has a responsibility to move breakthrough technologies developed in its mission-directed work into the marketplace, where the advances can positively affect the U.S. economy or other important national priorities.

EUV Lithography: A Partnership Defining Future Computers

Members of industry, government, and the news media gathered in April 2001 to mark completion of the first full-scale prototype lithography machine for making computer chips using extreme-ultraviolet (EUV) light. The technology, developed by Livermore, Sandia, and Berkeley national laboratories in collaboration with industry, is a breakthrough that will lead to microprocessors tens of times faster than today's most powerful chips and memory chips with similar increases in storage capacity.

Drawing on optical technology and precision engineering that supports its laser programs, the Laboratory brings to the project expertise in creating precision reflective optical coatings from multilayered materials, advanced optical testing methods, and defect inspection technologies. In the future, Livermore will directly benefit from the more powerful computers that will be made possible by EUV lithography.

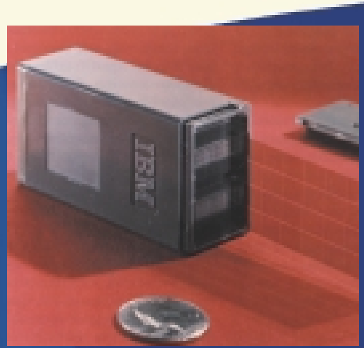
The prototype EUV lithography machine, called the Engineering Test Stand, resides at Sandia California. It is being used by industrial partners and lithography tool suppliers to refine the technology and prepare to create a prototype commercial machine that meets industry requirements for high-volume chip production. Prior to the April ceremony, the Engineering Test Stand demonstrated the capability to produce minute images on silicon. EUV lithography promises to allow manufacturers to print circuit lines at least as narrow as 0.03 micrometer (1/3,000th the width of a human hair), which will extend the current pace of semiconductor innovation at least through the end of the decade. Processors built using EUV technology are expected to reach speeds exceeding 10 gigahertz in 2008; by comparison, the fastest Pentium®4 processor today runs at 2 gigahertz.

EUV lithography is being pursued by a unique industry–government collaboration that began in 1997. It involves the three DOE national laboratories and a consortium of semiconductor companies called the EUV Limited Liability Corporation (LLC). The consortium, which has committed $250 million to the project, includes Intel, Motorola, Advanced Micro Devices, Micron Technology, Infineon Technologies, and IBM. In October 2001, EUV LLC extended the cooperative research and development agreement (CRADA) to 2005.

1950s

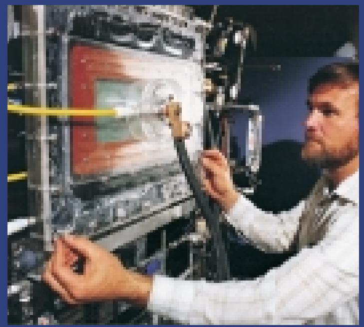
In 1954, Livermore acquired its second computer, the IBM 701, 12 times faster than the Univac-1. But even more speed was needed, so the Laboratory issued a formal request for proposals to the computer industry. Subsequently, supercomputer design has been driven largely by the needs of scientific computing, with the national laboratories at the forefront.

1960s



As computers grew in capability, Livermore's demands on the machines grew more sophisticated. The CDC 6600 allowed multiple users of the machine, and the Laboratory developed the first practical time-sharing system. Demand also arose for better data management and storage hardware, including the trillion-bit IBM Photostore system, with its miniature film "chip" storage.

1970s

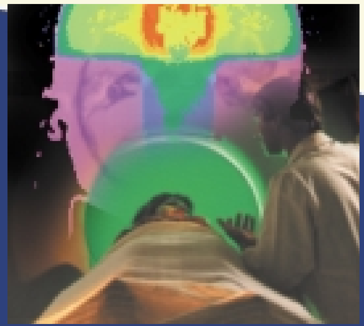


With the national energy crisis, the Laboratory became more engaged with U.S. industry in seeking innovations to increase energy supply and improve energy use. Livermore's special expertise and multidisciplinary approach have advanced technologies for exploration and retrieval of oil, gas, and coal; geothermal energy; fuel cells; and transportation systems.

1980s

A continuing technology transfer effort has characterized the Laboratory's development of progressively more powerful lasers—now NIF. Nova construction in the 1980s was a successful, long-term, major collaboration with U.S. industry that advanced the frontiers of laser technology and produced benefits far beyond initial expectations.

1990s



Through CRADAs and licensing, the Laboratory became engaged in a wide variety of projects with U.S. industry including health-care technologies such as the PEREGRINE system for cancer treatment and laser systems for various applications. Overall, researchers have won 85 R&D 100 Awards for technological achievements.

Being a Good Neighbor

The Laboratory and nearby communities have lived together and grown considerably over 50 years. Of paramount importance has been the Laboratory's commitment to provide every employee and neighbor with a safe and healthy environment in which to work and live. But being a good neighbor is more. As residents, employees and their families participate in a wide variety of civic endeavors. As an institution, the Laboratory contributes to the region's high-tech, global-outlook atmosphere and serves as a resource for scientific expertise—in 2001, dealing with the threat of terrorism.

Information, Education, and Assistance in 2001

The Laboratory's scientific and technical capabilities directly benefited the local community in the aftermath of September 11. With terrorist attacks dominating media headlines, the Laboratory provided technical support to government and local agencies and information to the public. Laboratory employees furnished information on the biology and detection of pathogens and on technologies for screening airline passengers and baggage.

At the height of the anthrax scares, Livermore's Forensic Science Center was called to characterize samples of unidentified powder found at Providian Corporation in nearby Pleasanton. Working through the night, Laboratory scientists conducted numerous chemical and biological analyses and concluded that the powder was harmless. Having a long history of assisting local, state, and federal law enforcement, the center also played a key role in the 2001 conviction of "Fremont bomber" Rodney Blach. Painstaking analysis of the electronics of the pipe bombs, including retro-engineering of the timing circuit electronics, provided key evidence linking the accused to the bombings.

Opening two new facilities augmented Laboratory technical and educational outreach efforts. In March, the University of California (UC) at Davis established the Edward Teller Education Center in collaboration with the UC Office of the President, Livermore, and UC Merced. The center will provide opportunities for professional development for K–12 science teachers. In August, the Laboratory became home to the Tri-Valley Enterprise Center. This center supports emerging companies and pilot operations of established firms by providing business services, facilities, training, and advice about technical and business issues. The Laboratory is one among several Bay Area technical sponsors of the center.

Additional assistance to local communities comes from volunteer work and donations collected through the Laboratory's HOME Campaign, which has raised more than $3.5 million for local and regional charities and nonprofit organizations over the last three years. The generosity of employees earned the Laboratory the Tri-Valley Community Champions Award in 2001 for contributing to the well-being of the community.

1950s

Science education efforts began when E. O. Lawrence encouraged his students to work at Livermore. The concept expanded in 1959 with summer programs for students and science teachers. Additional outreach programs launched in the 1960s included activities targeted at minority and underprivileged young people who had a knack for science.

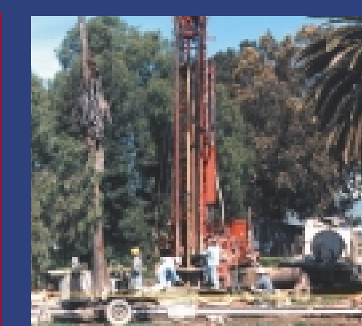
1960s

As the Laboratory and surrounding area grew, employees helped shape their communities through civic activities including volunteer work and, in cases, by becoming elected officials. In the 1960s and 1970s, four Laboratory employees served as mayor of Livermore, and one later served as mayor of nearby Brentwood.

1970s

In 1974, the Laboratory's annual charity collection became the Help Others More Effectively (HOME) Campaign. Launched each year with an employee noontime race, the HOME Campaign has steadily grown and now raises well over $1 million each year for San Francisco Bay Area and California Central Valley charities.

1980s



As concerns grew about the nation's environment, the Laboratory took steps to understand the extent of groundwater contamination due to activities dating from the 1940s, when the site was a naval air station. Novel technologies were developed and implemented to clean up the groundwater, and minimizing new waste became a high priority.

1990s

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Encouraged by DOE, the Laboratory expanded its work with U.S. industry—including many local businesses and start-up companies—through licensing and cooperative research and development agreements (CRADAs). Partnerships with UC campuses and work for the State of California also grew through the 1990s.

Award-Winning Science and Technology

Each year, the scientific and technological accomplishments of Livermore employees are recognized outside the Laboratory by prizes, awards, and front-page publicity. Some of these achievements are described here. In addition, in FY 2001, Laboratory scientists and engineers were responsible for 175 reported inventions, 112 patent applications, and 95 issued patents.

Edward Teller, one of the Laboratory's founders, was honored with the Hungarian Corvin Medal, bestowed by the Hungarian government for exceptional achievement in the arts and sciences. Delegates representing Hungarian Prime Minister Viktor Orban and the Hungarian consulates in San Mateo and Los Angeles read the proclamation in Hungarian. They were obviously pleased as Teller, who was born in Budapest in 1908, responded in his mother tongue. In the ceremony's opening remarks, given in both languages, the diplomats explained that Prime Minister Orban revived the Corvin Medal this year; it was last awarded in 1930.

The American Nuclear Society named laser and plasma physicist Mordy Rosen as the recipient of one of two Edward Teller Medals for 2001.

The laboratory garnered three R&D 100 Awards for:

- The Gene Recovery Microdissection Process headed by Matthew Coleman, Allen Christian, and James Tucker;
- The Continuous Laser Glass Melting Process by Paul Ehrmann, William Steele, Charles Thorsness, Michael Riley, Tayyab Suratwala, and Jack Campbell in partnership with Hoya Corporation USA and Schott Glass Technologies; and
- The Lasershot Marking System by Brent Dane, Lloyd Hackel, Hao-Lin Chen, John Halpin, and John Honig in partnership with Metal Improvement Company Inc.

Dave Cooper, former associate director for Computation, received DOE's highest civilian recognition, the Distinguished Associate Award, for his leadership of NNSA's ASCI program, the effort to simulate nuclear weapons performance with computer models.

The American Optical Society awarded a fellowship posthumously to longtime Livermore researcher Howard Powell for "seminal contributions to the research and development of high-energy, high-peak-power, and high-average-power solid-state lasers for inertial confinement fusion, military applications, and commercial utilization."

Clint Logan and Salvador Aceves were named fellows of the American Society of Mechanical Engineers.

Craig Smith, leader of Fission Energy and Systems Safety Program, was named an American Nuclear Society fellow for "outstanding accomplishments in nuclear health, safety, and regulation and radiation protection and waste management."

Peter Beiersdorfer, David Munro, Karl van Bibber, and Siegfried Glenzer were named fellows of the American Physical Society.

Quazi Hossain was named a fellow by the American Society of Civil Engineers for distinguished service as chairman of the ASCE Working Committee on the High-Level Radioactive Waste Repository.

The U.S. Environmental Protection Agency's Greening the Government Award was given to Chemistry and Materials Science directorate's Space Action Team for work in recycling materials in Livermore decontamination and demolition projects.

The Boeing Award for Infrared Spectrometry was given to a Laboratory team for the Remote Optical Characterization Sensor Suite (ROCSS), based on the Laboratory's unique capabilities in infrared spectrometry.

Eli Rotenbert received the Peter Mark Memorial Award of the American Vacuum Society for furthering knowledge of nanophase and reduced dimensionality systems by creative use of angle-resolved photoemission.

John Elmer and Joe Wong received the William Spraragen Memorial Award from the American Welding Society for valuable contributions in welding research and advancement of the welding industry.

Brendan Dooher was the first Laboratory employee to be selected for a National Academy of Engineering Fellowship.

The Medical Technology Program—including Stephen Lane, Tom Peyser, Chris Darrow, Natasha Zaitseva, Joe Satcher, and Doug Cary—and the Industrial Partnerships and Commercialization Office's Kevin O'Brien and Connie Pitcock received DOE's Bright Light Award and a Federal Laboratory Consortium Excellence in Technology Transfer Award for collaborations and transferring glucose monitoring technology to MiniMed Inc. of Sylmar, California.

DOE/Oakland Operations Pollution Prevention Awards were given for five projects: specific-depth groundwater sampling (Greg Howard), take-back buy-back of AVLIS chemicals and materials (Edward Fehring), NIF optics cleaning process (the NIF design team), reducing hazardous waste and emissions (the Fleet Maintenance Facility), and reducing waste at the Site 300 firing tables (Defense and Nuclear Technologies staff).

Claire Max, Elbert Branscomb, John Nitao, and George Kwei earned Edward Teller Fellowships for 2001. Edward Teller awards are presented by the Laboratory director for significant accomplishments.

The Laboratory was awarded a DOE Technology Innovation Award for work developing a hydrogen fuel tank for next-generation automobiles.

People, Programs, and Operations

Lawrence Livermore's principal asset is its workforce. Through a long association with the University of California, the Laboratory has recruited a world-class workforce and sustained a tradition of scientific and technical excellence. With approximately 8,000 employees and the skills and facilities of a small city, Livermore benefits from the efficient and productive services provided by its staff and conducts safe, secure operations.

Outstanding Employee Performance

The dedicated effort of all employees contributes to the Laboratory's success. Efficient business practices; well-run facilities and infrastructure; and safe, environmentally compliant, and secure operations at Livermore go hand in hand with breakthroughs in science and technology. We strive to set a standard of excellence in administrative and operational activities among high-technology research and development institutions. Over the past decade, the Laboratory has markedly improved operations by using performance-based management as a vehicle for benchmarking against others, providing better services and support, and lowering costs. In areas such as Procurement and Property Management, Livermore is currently used as a benchmark organization for the DOE complex.

Safety, environmental compliance, and security are high priorities at Livermore. DOE's Integrated Safety Management System has been implemented here. Now, the Laboratory is working with the National Nuclear Security Administration (NNSA) and University of California (UC) to implement an Integrated Safeguards and Security Management System. Those systems plus expanded security measures since September 11, 2001, are key efforts to ensure that great science and security can continue working together to carry out the Laboratory's mission.

The importance of quality administration and operations to the success of the institution is reflected in significant high-level organizational changes made by the Laboratory director in early 2001. Three new directorates were created—Safety, Security, and Environmental Protection; Administration; and Laboratory Services—and, in May 2001, associate directors were appointed to lead the new organizations. The changes are ensuring high-level attention to important Laboratory operational issues. In addition, recommendations from a 2001 Laboratory survey are being implemented to ensure that contemporary needs of employees are met.

For the first time, the Laboratory achieved an overall rating of "outstanding," as assessed by NNSA. The annual assessment, covering the period October 1, 2000, to September 30, 2001, is an integral part of UC's contract to manage its DOE laboratories. The Laboratory is appraised in Laboratory Management, Science and Technology, and Administration and Operations—and received an "outstanding" rating in each.

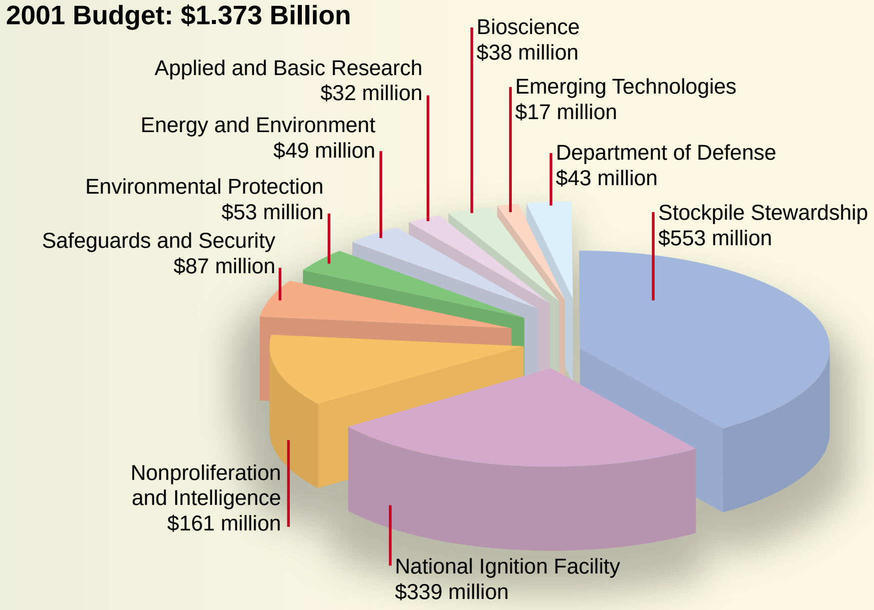
Serving the Laboratory's Sponsors

Most of Livermore's $1.37-billion budget for FY 2001 was designated for research and development activities in program areas supporting DOE missions.

As a national security laboratory, Livermore is part of the Department of Energy's NNSA. Much of the Laboratory's funding comes from the NNSA Office of Defense Programs for stockpile stewardship activities. Support for national security work also comes from the NNSA Office of Defense Nuclear Nonproliferation, various Department of Defense sponsors, and other federal agencies.

As a multiprogram laboratory, Livermore applies its special capabilities to meet important national needs. Activities are pursued for other DOE programs, principally Environmental Management, and the Offices of Science; Civilian Radioactive Waste Management; Nuclear Energy, Science, and Technology; and Security and Emergency Operations. Non-DOE sponsors include federal agencies (such as the National Aeronautics and Space Administration, Nuclear Regulatory Commission, National Institutes of Health, and Environmental Protection Agency), State of California agencies, and industry.

FY 2001 Budget: $1.373 Billion

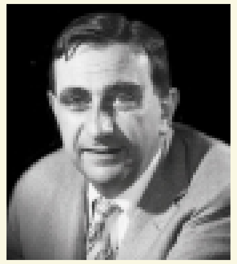


Serving the Nation for 50 Years . . .

Now a part of the Department of Energy's National Nuclear Security Administration, Lawrence Livermore National Laboratory has been managed by the University of California since its inception. For 50 years, national security has been the Laboratory's important defining mission. Researchers today continue the multidisciplinary team-science tradition of founder E. O. Lawrence (at left) and the commitment of first director Herbert York and his team to be a "new ideas" laboratory.

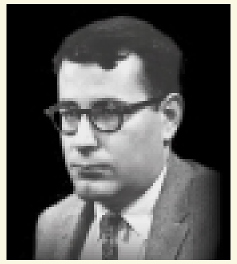
Herbert F. York
(1952–1958)

Selected by E. O. Lawrence to head the new laboratory, York faced the challenges of planning Livermore's technical programs and recruiting its staff. During his years as director, the staff grew from around 100 to some 3,600, and the annual budget increased from $3.5 million to $45 million.



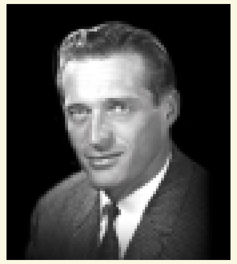
Edward Teller
(1958–1960)

The efforts of Teller and E. O. Lawrence led to the founding of the Laboratory. Teller served as director while the Laboratory developed the Polaris missile warhead—its first triumphant success—and the nation entered into an international nuclear test moratorium.



Harold Brown
(1960–1961)

Serving as director during the nuclear test moratorium, Brown was a driving force behind the acquisition of new nonnuclear experimental facilities and further expansion of Livermore's already impressive capabilities for simulating nuclear explosions on computers.

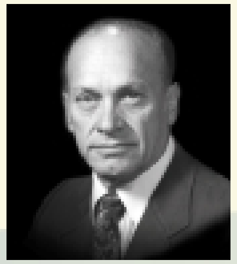


John S. Foster
(1961–1965)

With the end of the moratorium, nuclear testing resumed—all underground after 1962. Under Foster's tenure, nuclear designs improved in terms of safety and security as well as performance. The Laboratory also established a biomedical program and an on-site branch of UC Davis.

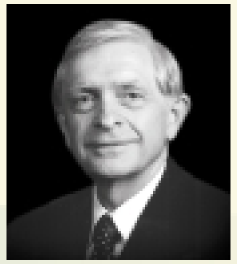
Michael M. May
(1965–1971)

While May served as director, warheads for the Poseidon, Spartan, and Minuteman missiles were developed. Project Plowshare, which was winding down, laid the foundation for energy-related and environmental programs. In 1971, the Laser Program was established and grew rapidly.



Roger E. Batzel
(1971–1988)

Batzel served as director for more than one-third of Livermore's history. In the 1970s, work in energy, environment, and fusion grew to over half the Laboratory's budget. In the 1980s, weapons development and defense work regained preeminence, and bioscience and laser research blossomed.



John H. Nuckolls
(1988–1994)

The Laboratory began a transition to the post–Cold War era. Nuckolls established the Nonproliferation, Arms Control, and International Security directorate, and the foundation was laid for the Stockpile Stewardship Program to maintain weapons in the absence of nuclear testing.

C. Bruce Tarter
(1994–2002)

The Stockpile Stewardship Program began, and Livermore acquired vastly improved capabilities—terascale computers and NIF. Programs to counter proliferation and terrorism grew and are contributing to post–September 11 national security. Tarter plans to step down as director in 2002.

. . . As a Part of the University of California

In January 2001, the Regents of the University of California approved an extension of the contract with DOE to manage Livermore and Los Alamos national laboratories. The University manages the two laboratories and Lawrence Berkeley National Laboratory as a public service to the nation. When the performance-based management contract was extended to September 30, 2005, UC created the position of Vice President for Laboratory Management. In May, John P. McTague was selected to serve.

Livermore's association with UC helps to ensure scientific and technical excellence, and it serves as a vehicle for recruiting new employees. As the Laboratory began operation, many of the founding scientists and engineers were recruited from Berkeley. Now, many strong ties connect Livermore and UC campuses. UC Davis Department of Applied Science has had a branch at the Livermore site since the 1960s, and the Laboratory is working closely with UC to establish research programs at the University's newest campus at Merced. In addition, Livermore has five research institutes, where students and faculty from UC and elsewhere work collaboratively with Laboratory researchers. Programs, supported by the fee UC receives for managing the laboratories, include cooperative research efforts between the UC laboratories and campuses to address issues that are important to the State of California.

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50 Years of Making History. . .

50 Years of Making a Difference

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